Session on Monitoring and Data Assimilation

Opportunities for

Integrating Science, Research with Multi-Objective Management

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Center for Ecohydraulics Research
University of Idaho

Session on Monitoring and Data Assimilation

Presentation Outline

- CBDA as a 'Model'
- The role of social science research in restoration and management of large-scale systems
- Trends in Community Science
- Enabling Technologies
  - Sensors and Sensor Networks
  - Cyber-infrastructure
  - Data Synthesis and Data Mining
  - Integrated Modeling-Monitoring (Real-time modeling)
- Example 1: Detecting change due to natural and anthropogenic disturbance
- Example 2: Modeling to prioritize restoration actions at the watershed scale
- Summary of Discussion Items

CBDA – A national and global model?

CENTRE FOR PATAGONIA ECOSYSTEMS RESEARCH
CIEP

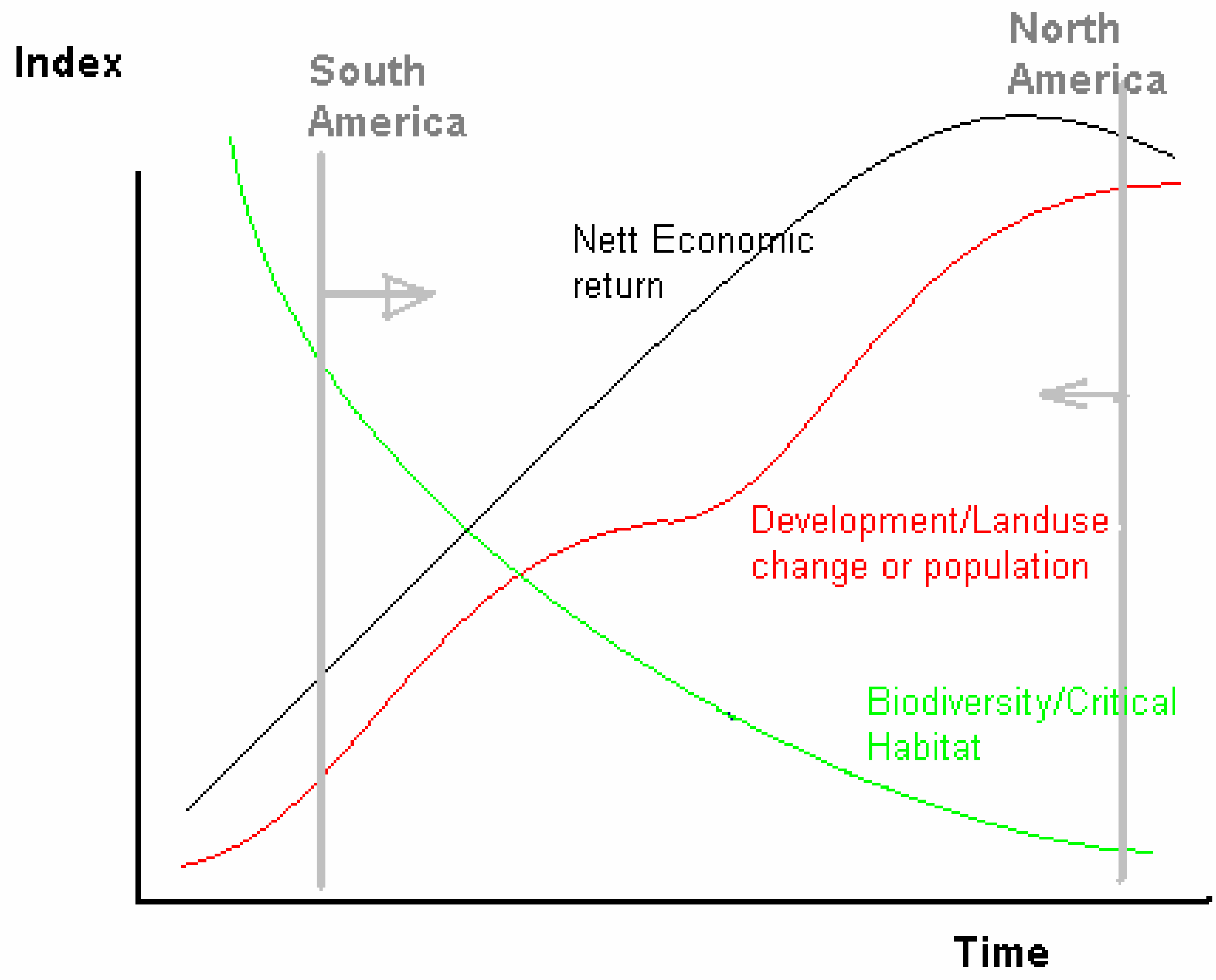
The Concept

Currently the Aysen Region of Chile is one of the most minimally disturbed watersheds, airsheds and ecosystems in Chile or the world.

This Region is the subject of massive development pressures and could change irreversibly in the next few years.

The GRAND CHALLENGE. Can this development be managed in a way that preserves biodiversity, quality of life and the integrity of the ecosystem for future generations?

We intend to develop a center that will provide fundamental and applied research to try and make this Region a global model for wise and sustainable development


Index
South America
North America
Nett Economic return
Development/Landuse change or population
Biodiversity/Critical Habitat
Time

ASCE Professional Code of Ethics

Fundamental Canons

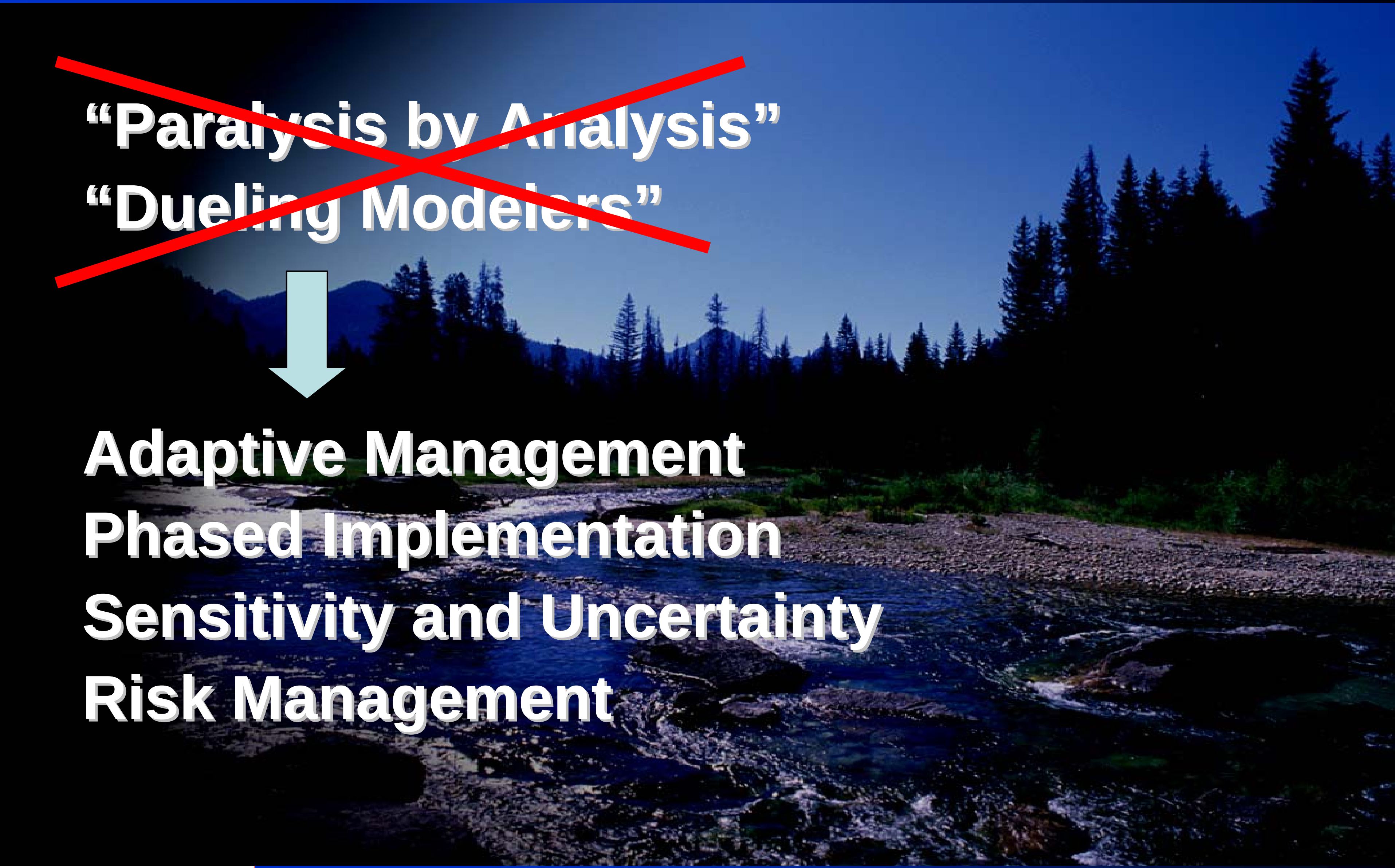
Engineers shall hold paramount the safety, health and welfare of the public and shall strive to comply with the principles of sustainable development in the performance of their professional duties.

Guidelines to Practice Under the Fundamental Canons of Ethics

CANON 1.

- Engineers shall hold paramount the safety, health and welfare of the public and shall strive to comply with the principles of sustainable development in the performance of their professional duties.
- Engineers should seek opportunities to be of constructive service in civic affairs and work for the advancement of the safety, health and well-being of their communities, and the protection of the environment through the practice of sustainable development.
- Engineers should be committed to improving the environment by adherence to the principles of sustainable development so as to enhance the quality of life of the general public.

Barriers



~~"Paralysis by Analysis"~~

~~"Dueling Modelers"~~

Adaptive Management

Phased Implementation

Sensitivity and Uncertainty

Risk Management

Living River Strategy : Napa River Watershed

A success story

Napa River-55 Miles from San Francisco Bay to Calistoga

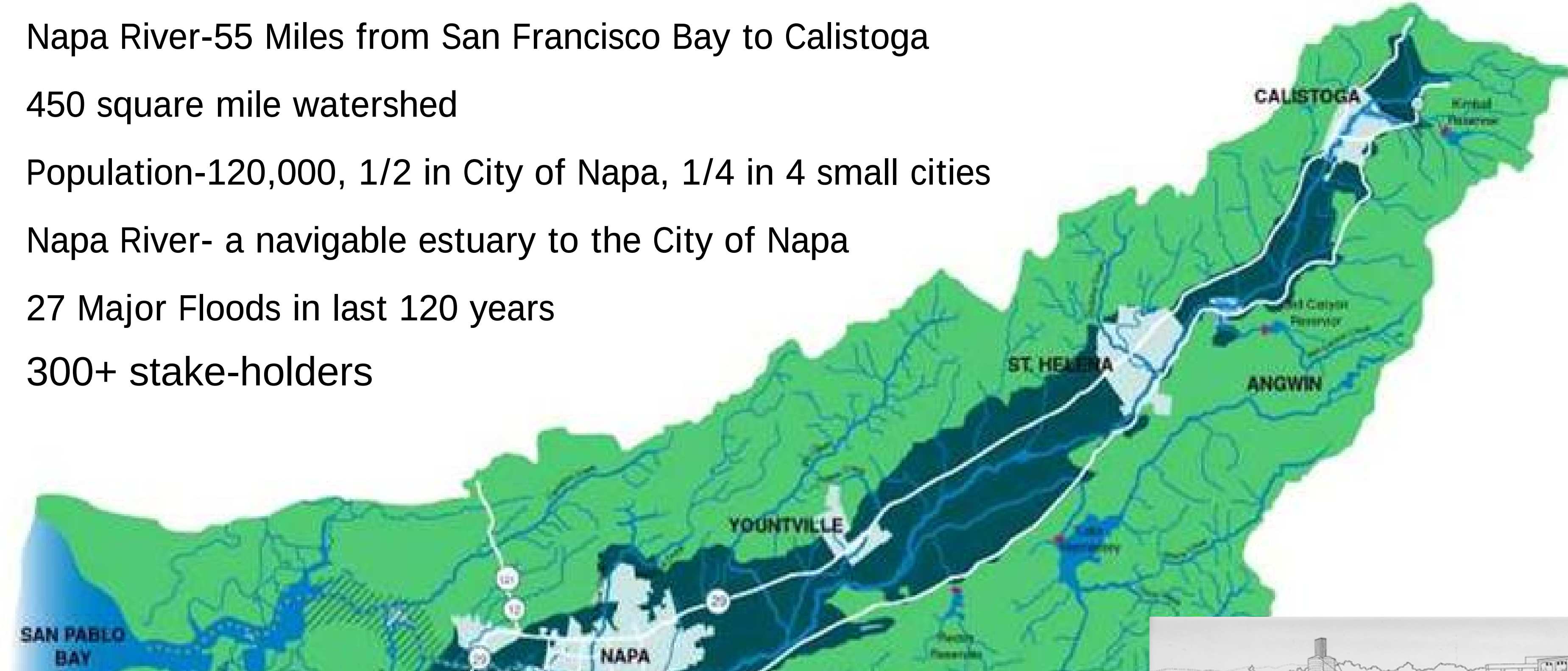
450 square mile watershed

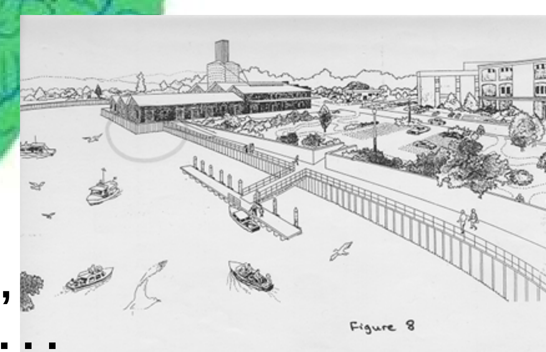
Population-120,000, 1/2 in City of Napa, 1/4 in 4 small cities

Napa River- a navigable estuary to the City of Napa

27 Major Floods in last 120 years

300+ stake-holders





California Coastal Conservancy, CDFG, Friends of the Napa River, RWQCB, Napa County, City of Napa, US Army CoE, USFWS, ...

Gainesville Sun: April 8, 2005

Saving an Ecosystem?

- The efforts to restore the Everglades have reached a standstill.
- The US Army Corps of Engineers is behind schedule with its restoration of the Florida Everglades. It is over budget. It has "missed almost every milestone". That criticism does not come from tree hugging ecologists either. It's from within the Corps.

Stake-holders and public perception

Stakeholder Involvement

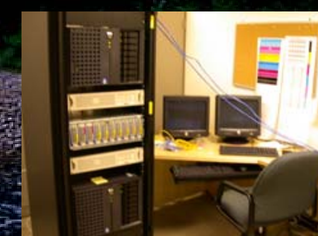
Status quo beneficiaries
Uncertainty for the future
Communication
Information accessibility and control
Transparency
Defensible science
Institutional collaboration

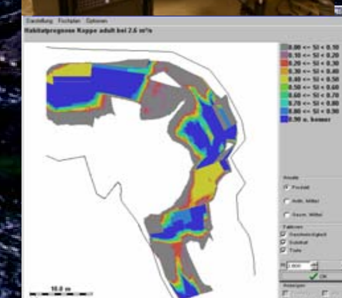
***It is the people*! [NSF Project Science]**
G. Sanders

Integration of Sensor Networks, Cyber-Infrastructure, Management and Policy

Conjunctive Administration of Water Rights

Idaho DWR





Trends in Community Science

- Environmental Observatories
  - LTER
  - NEON
  - Hydrological Observatories (CUASHI)
  - OOI
  - CLEANER
  - NEES
- Common features
  - Driven by scientific and engineering communities
  - Cyber-infrastructure emphasis
  - Inclusive
  - Grand Challenges
  - Sensor and Sensor Networks
  - Paradigm shift in simulation models
    [Closure relations vs calibration, data mining]

Sensors and Sensor Networks

Sensors for Environmental Observatories

NSF Workshop: November 2004
University of Washington

Objectives:

- Map out strategies to ensure sensor technologies are developed for long-term autonomous deployment;
- Build a sensor capacity for the environmental observational networks for the high priority parameters identified within research community reports;
- Build a multidisciplinary community of researchers who will help interested federal agencies develop research plans that meet these needs; and
- Provide community guidance to help shape future NSF program announcements in this area.

www.wtec.org/seo

Co-chaired by:
Peter Arzberger
University of California at San Diego
James Bonner
Texas A&M University
David Fries
University of South Florida
Arthur Sanderson
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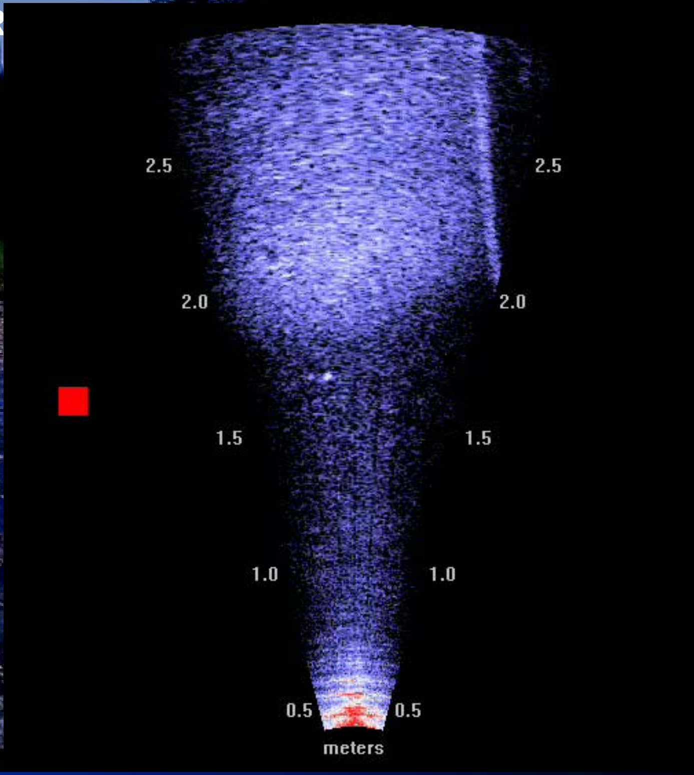
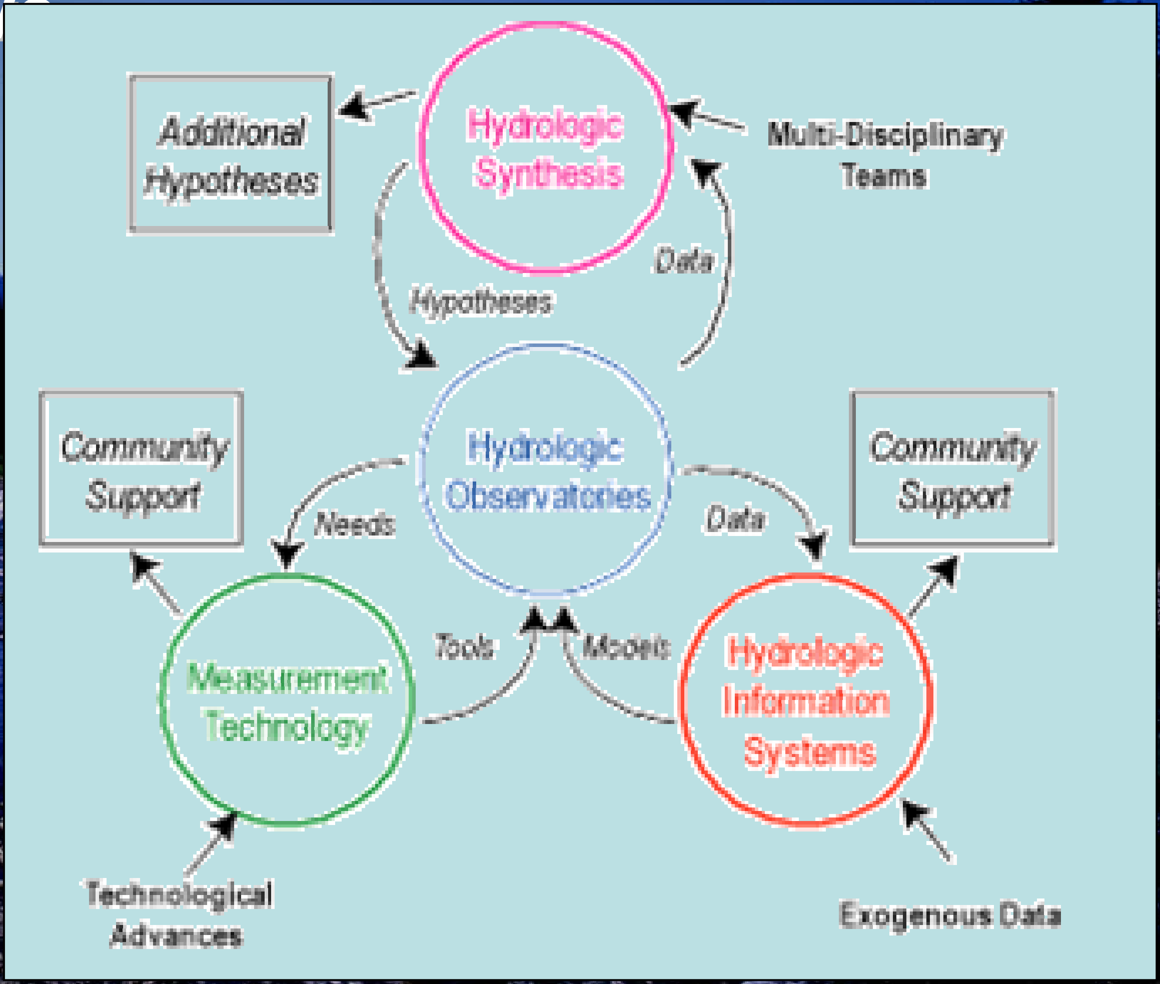


HydroView – Hydrological Observatories

Mutually supportive elements

- Observatories
- Instrumentation
- Informatics
- Synthesis

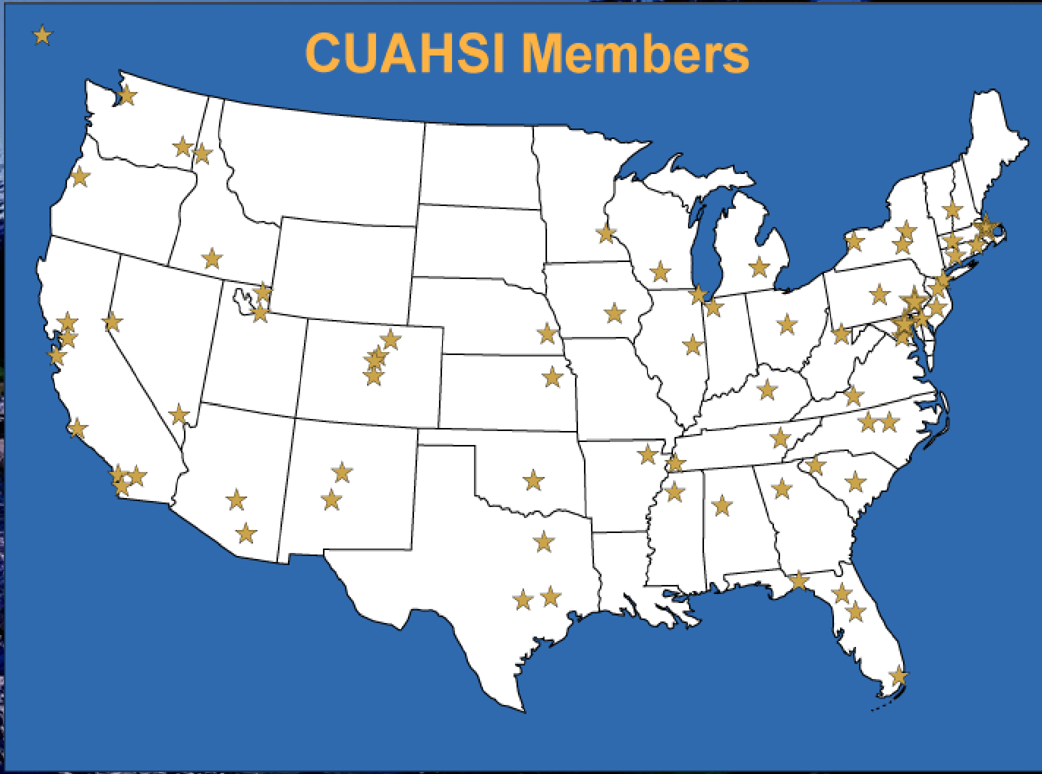


Jon Duncan

CUASHI, June 2004

Who is CUAHSI?

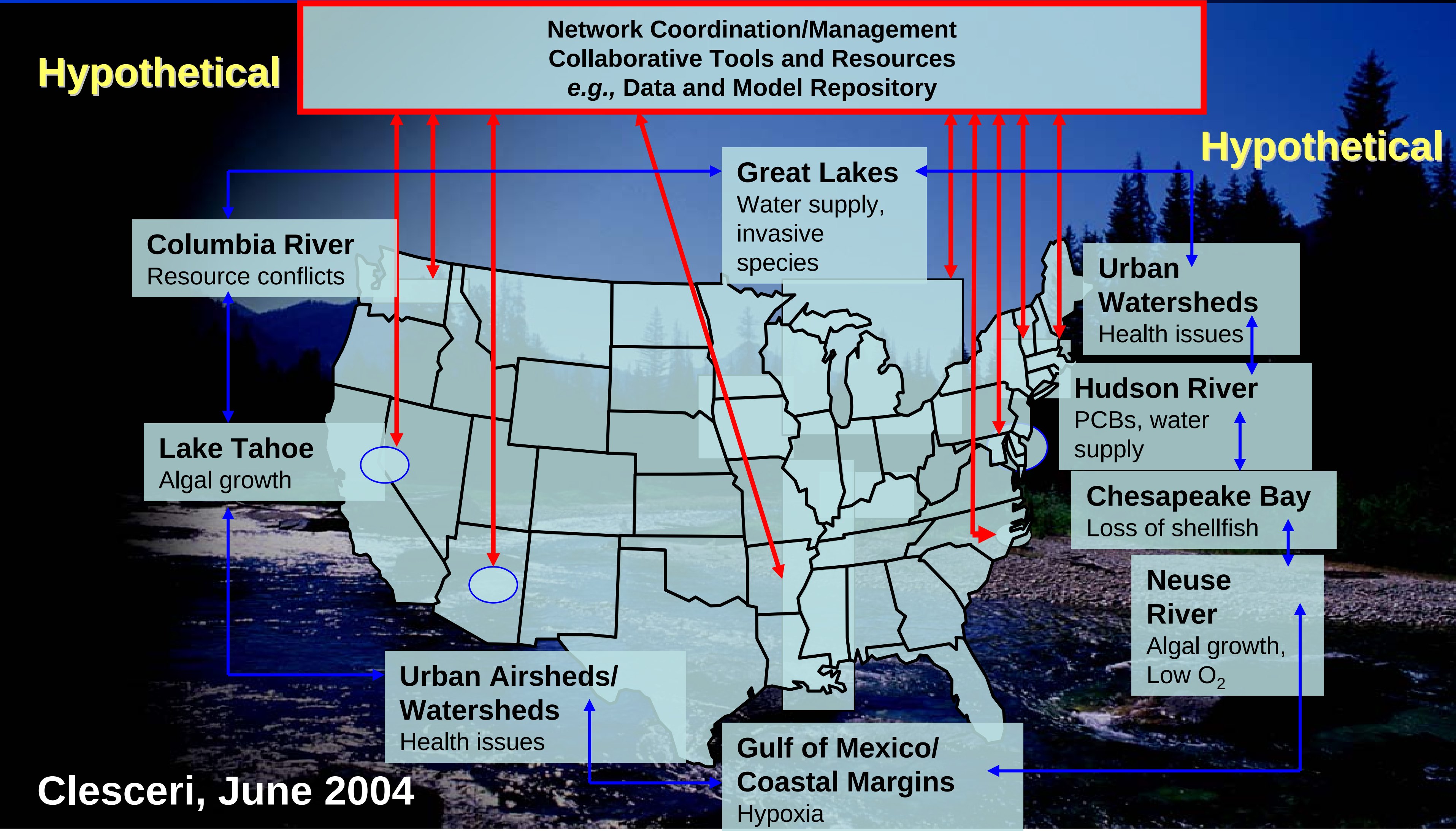
- A consortium of 90 research universities and 1 affiliate member
- Incorporated June, 2001 as a non-profit corporation in Washington, DC



Jon Duncan

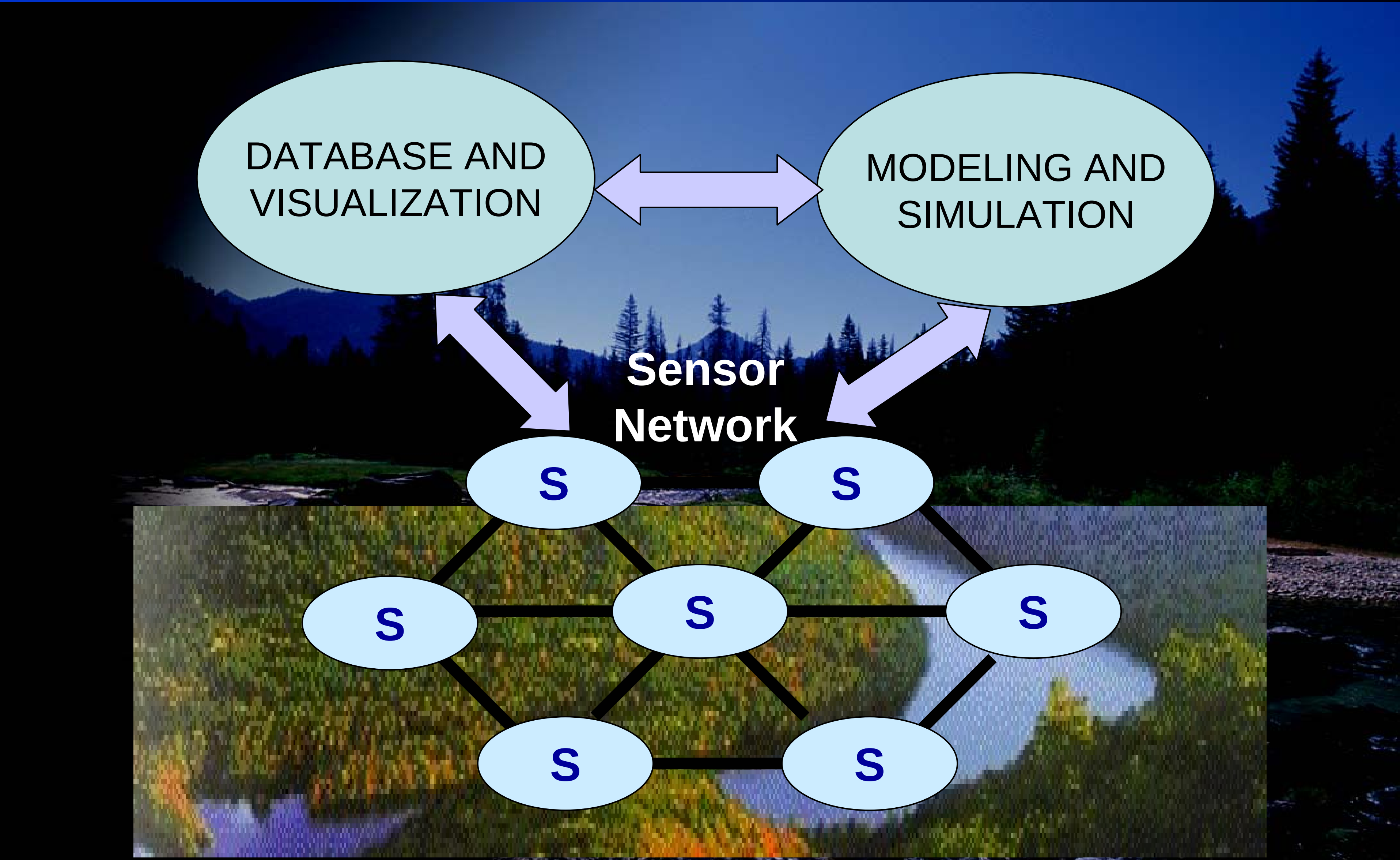
CUASHI, June 2004

Key Focus: fundamental understanding of adaptive dynamic management of human-dominated complex environmental systems through collaborative modeling and knowledge networks.



CLEANER Network and Examples of Stressed Environmental Systems

Adaptive Dynamic Management: Core of EOs



3rd NSF-ENG
Cyberinfrastructure Workshop
April 22-23 Drexel University

For workshop report and additional information visit website

http://thor.cae.drexel.edu/~workshop

PPVs and presentations are posted

M. Piasecki, June 2004

NSF-ENG working definition of CI:

Cyberinfrastructure is a national network of resources that:

- **provides broad and easy access to shared and maintained repositories for data, models, and tools.**
- **includes connectivity with shared facilities for experimentation and computation.**
- **enables reliable visualization and information extraction from multimedia data resources and libraries.**
- **supports real-time data flows and distributed collaboration.**
- **ensures that applications and domain communities can form and grow, and that efforts develop with interoperability.**

NSF-ENG has a three-fold role regarding CI:

- ENG researchers develop and apply the fundamental technologies that are needed to create the CI resources and connectivity.

- Community development in ENG research and education will introduce culture changes and establish requirements for cyberinfrastructure performance.

- ENG research and education communities will engage the CI as a 21st century platform for discovery and innovation.

And - engineers provide the systems and operations knowledge needed to design and construct the CI as the reliable infrastructure it must become.

Further Details

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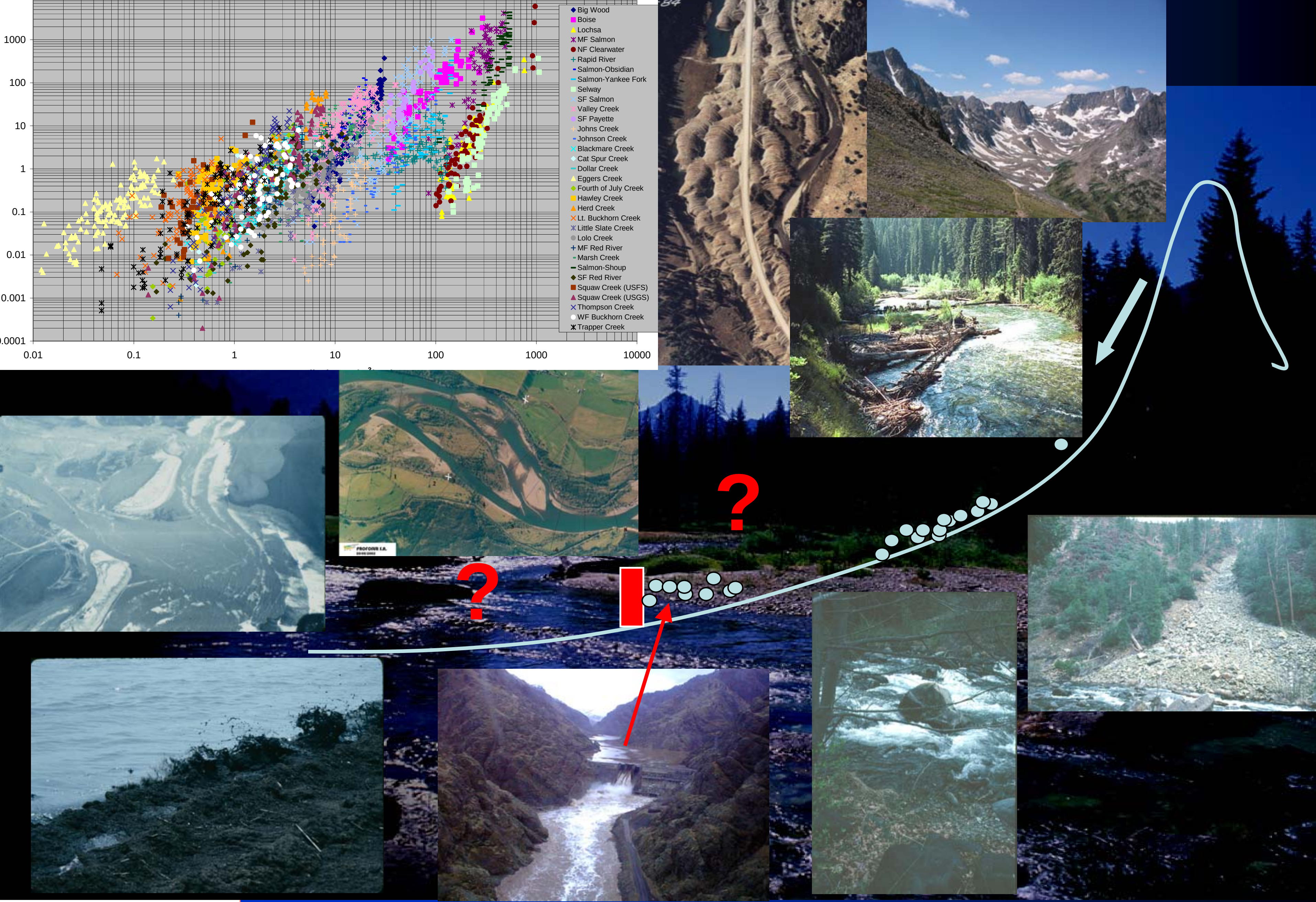
Detecting Change due to Natural and Anthropogenic Disturbance





CALIFORNIA
BAY-DELTA
AUTHORITY

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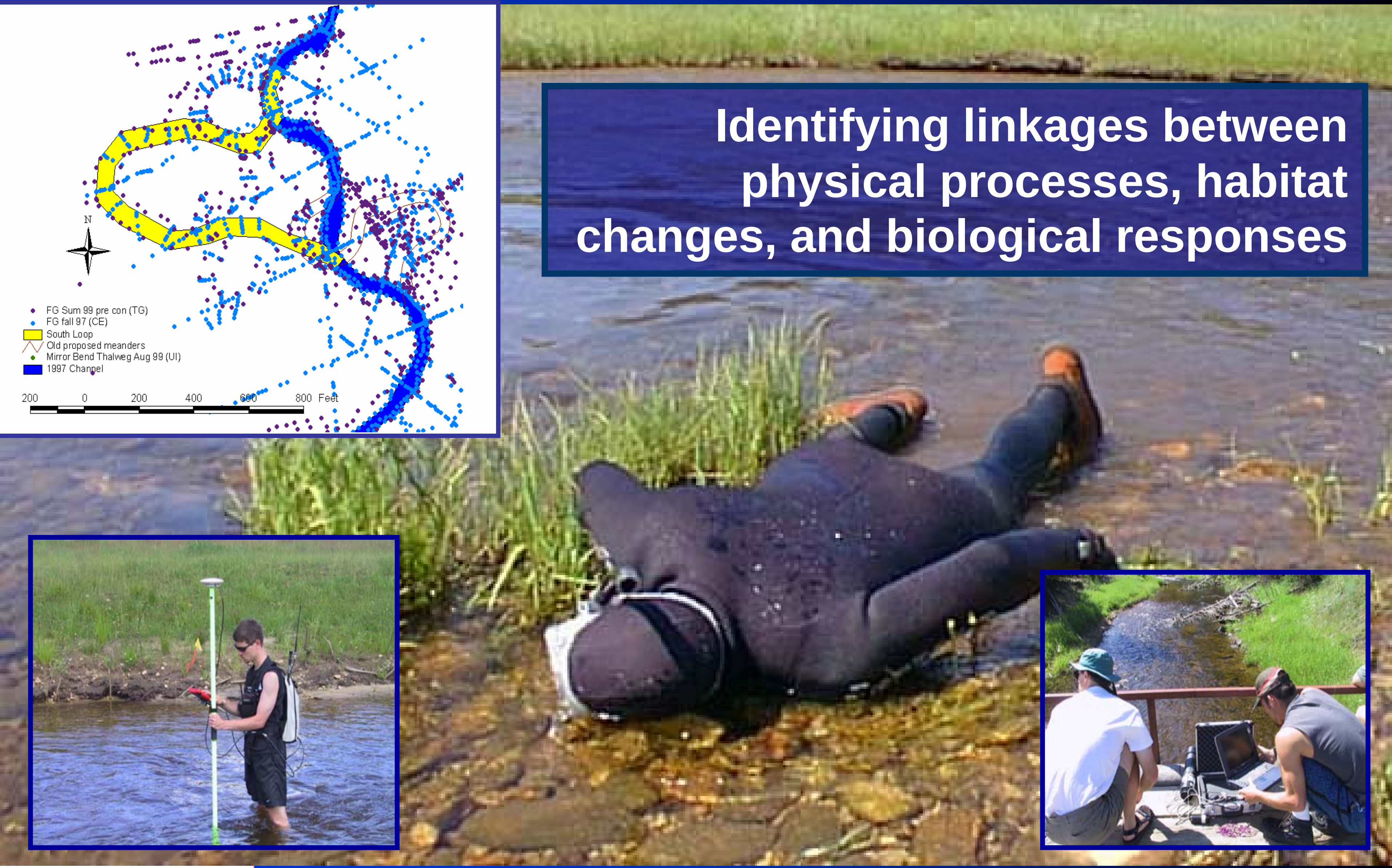
Session on Monitoring and Data Assimilation

Monitoring and Evaluation



Identifying linkages between physical processes, habitat changes, and biological responses

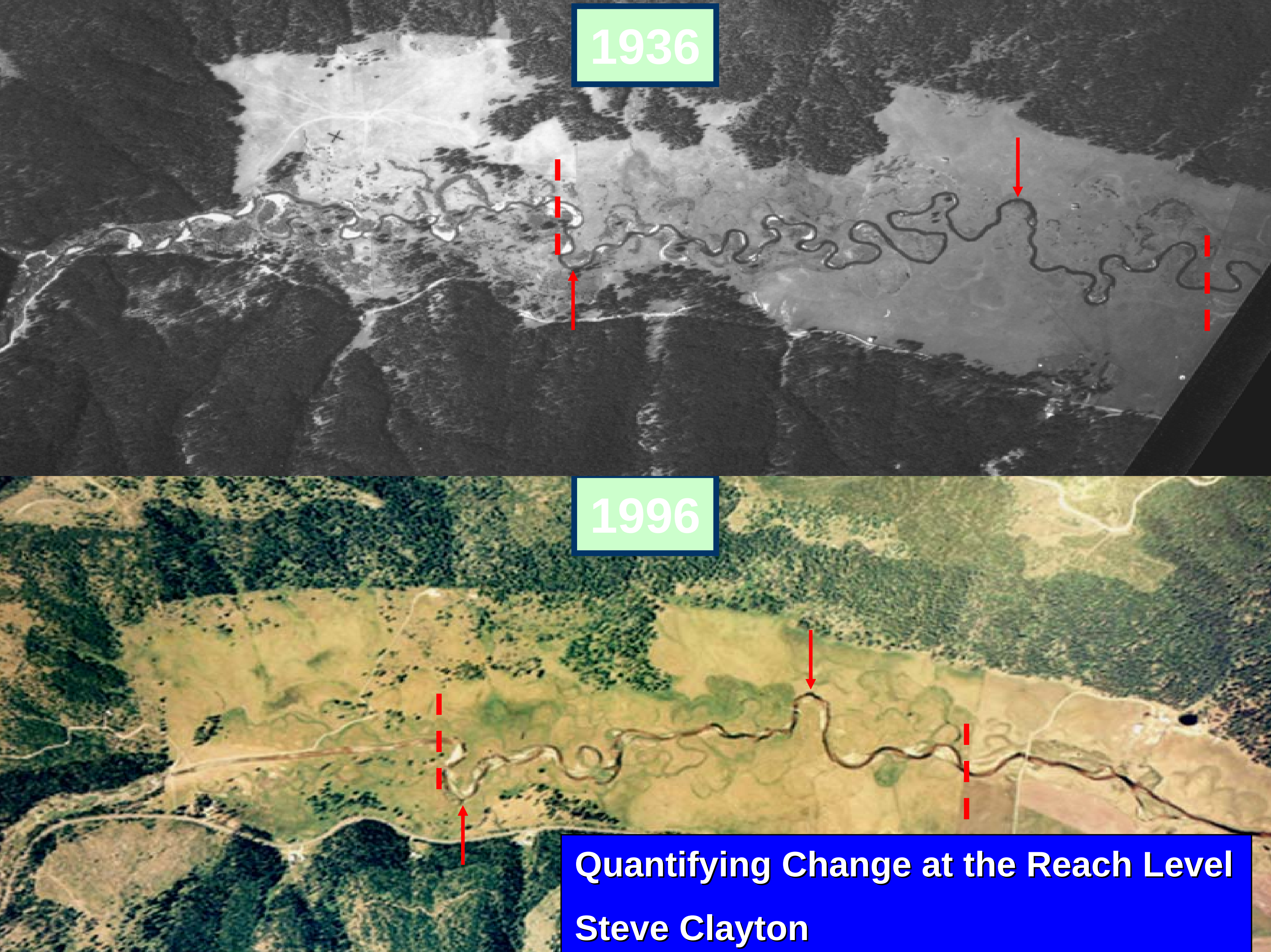
Challenges of ecological restoration monitoring

- Spatially-sparse, short-duration data sets
- Little or no pre-restoration data
- Detectable change from restoration is a small percentage of diurnal, seasonal, or inter-annual variability
- Effects occur at multiple spatial and temporal scales
- Individual restoration actions may have cumulative responses that are less predictable

<table>
<tr><th rowspan="2">Restoration goal</th><th rowspan="2">Typical restoration activity</th><th colspan="3">Individual physical responses</th><th colspan="2">Cumulative responses</th></tr>
<tr><th>Shear stress</th><th>Particle size</th><th>Thermal gain</th><th>Physical</th><th>Biological</th></tr>
<tr><td>“Restore channel geometry”</td><td>Reduce w/d</td><td>+</td><td>+</td><td>-</td><td rowspan="2">?</td><td rowspan="2">?</td></tr>
<tr><td>“Restore channel slope and sinuosity”</td><td>Increase length</td><td>-</td><td>-</td><td>+</td></tr>
</table>

Questions inherent in ISRP recommendations

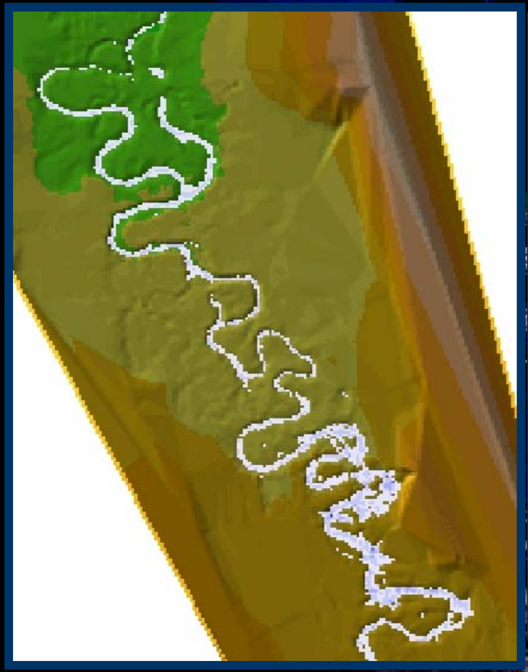
- When a sub-basin is identified as critical, how should restoration activities be prioritized?
- How can the ecological benefits be demonstrated at the watershed scale?
- How can the ecological benefit to various indicator species be quantified in the local region of the restoration?



Quantifying Change at the Reach Level

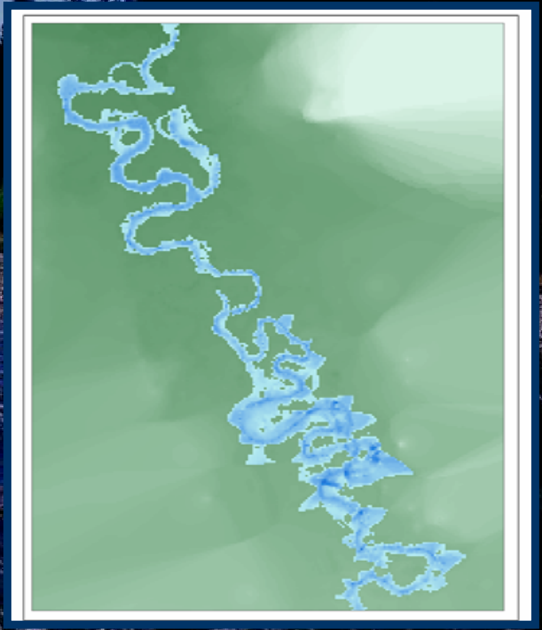
Steve Clayton

Hydroperiod Analysis (Wetness of Meadow)

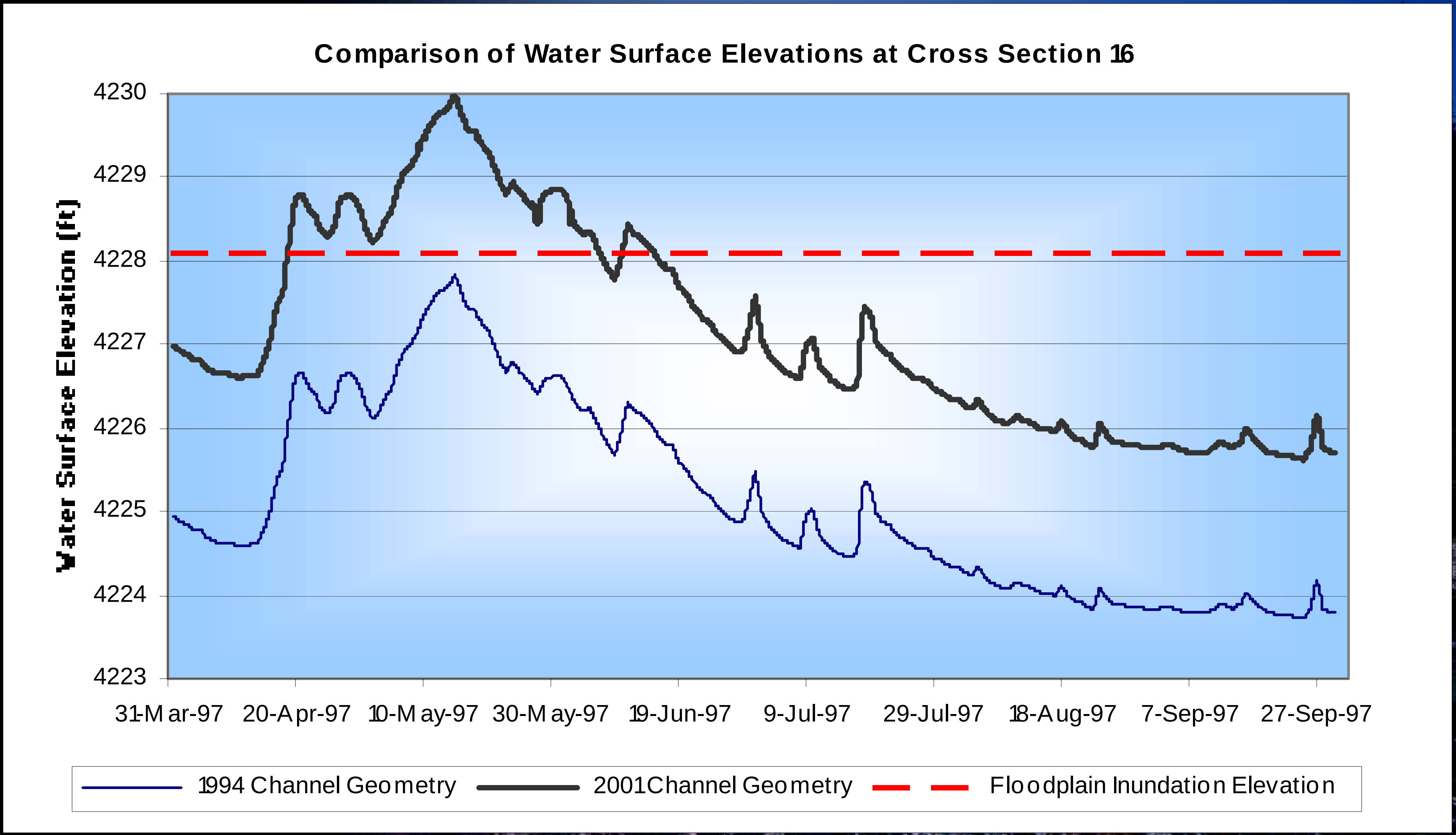


1994 Channel Geometry

2000 Channel Geometry



Hydroperiod Analysis



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Monitoring Framework

Flow
Sediment Inflow
Ocean Conditions
Dams

Independent External Variables

Channel Length
Channel Section

Physical Forcing Variables

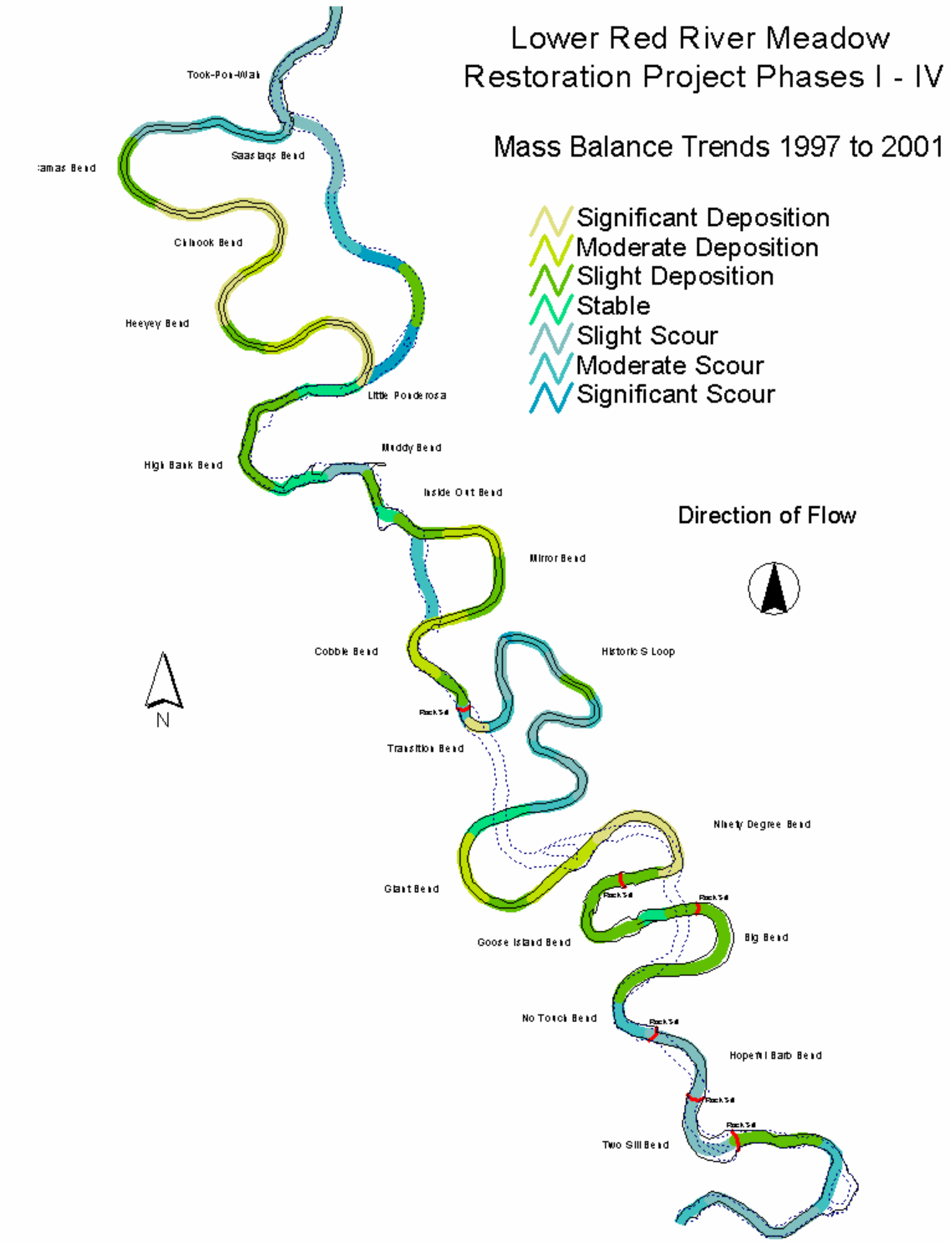
Hydraulic Parameters
Geomorphic Parameters
Sediment Transport/substrate
Roughness
Hydroperiod
Temperature

Physical Response Variables

Biological Response Variables

Riparian Vegetation
Macroinvertebrates
Resident and Anadromous Fish

Performance Assessment:
Physical Processes, Biological Observations, Linkages



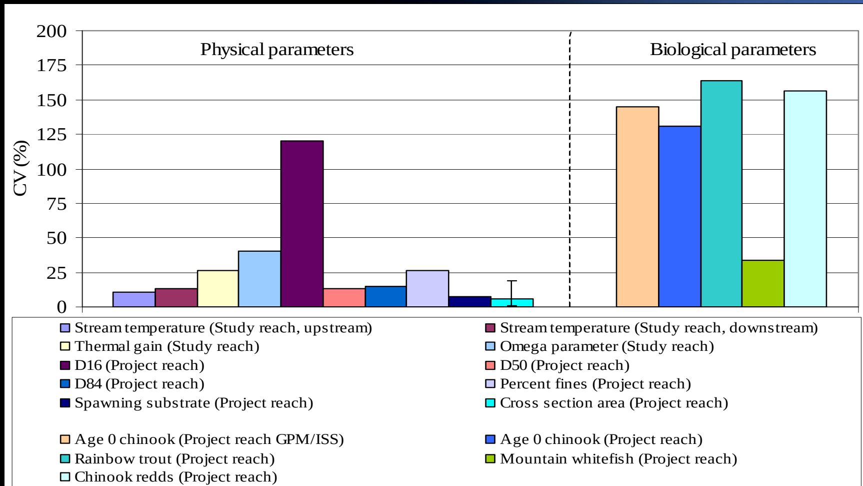
Physical Parameters

Gradient
Sinuosity
Sediment Balance
Aggradation/Degradation
Groundwater Level
Channel Dimensions
Bank Erosion
Substrate
Hydraulic Parameters
Hydroperiod

Biological Parameters

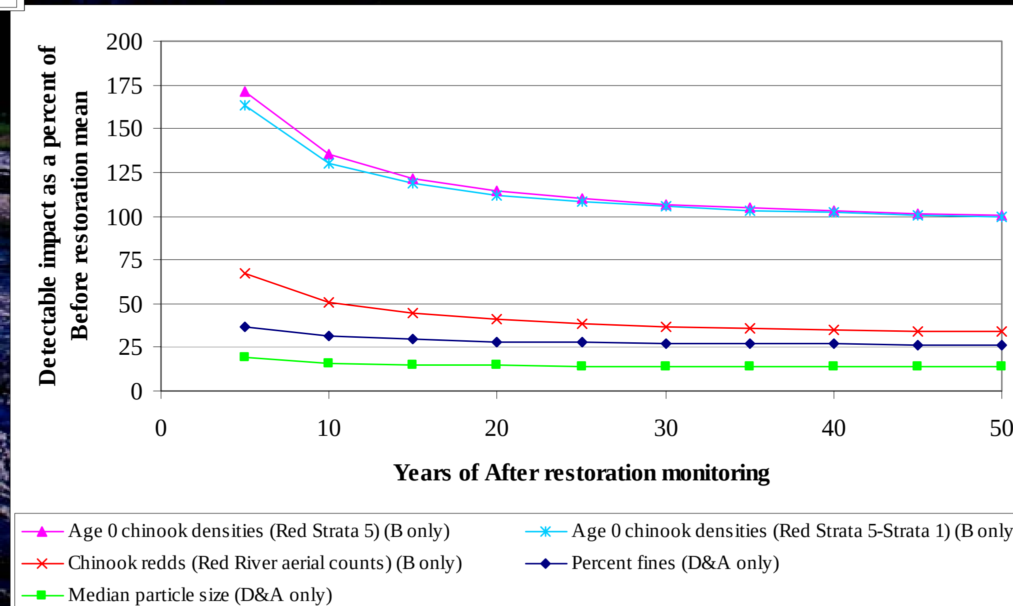
Parr Snorkeling
Redd Surveys
Bird Surveys
HEP Transects
Riparian Surveys
Macroinvertebrates

Detectable impact as a function of years of post-restoration monitoring for selected parameters with variance calculated from before (B) or during and after (D&A)

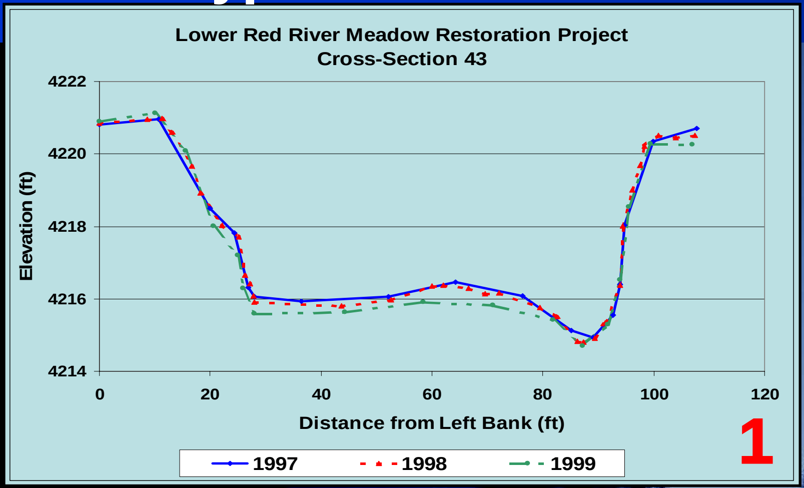


Further details: Steve Clayton

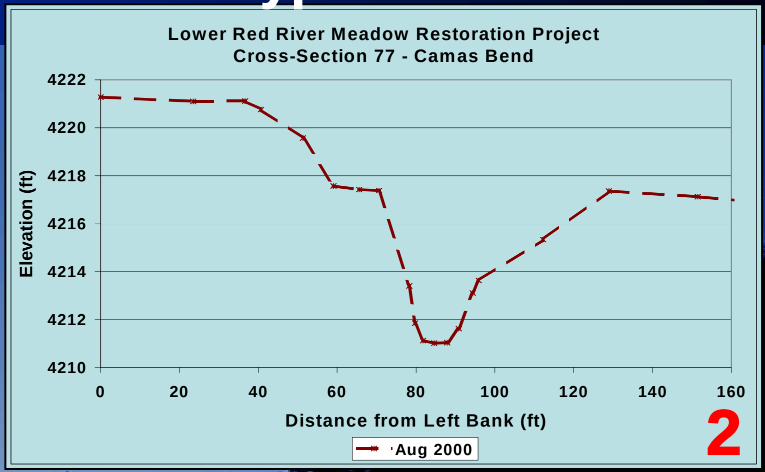
sclayton@uidaho.edu



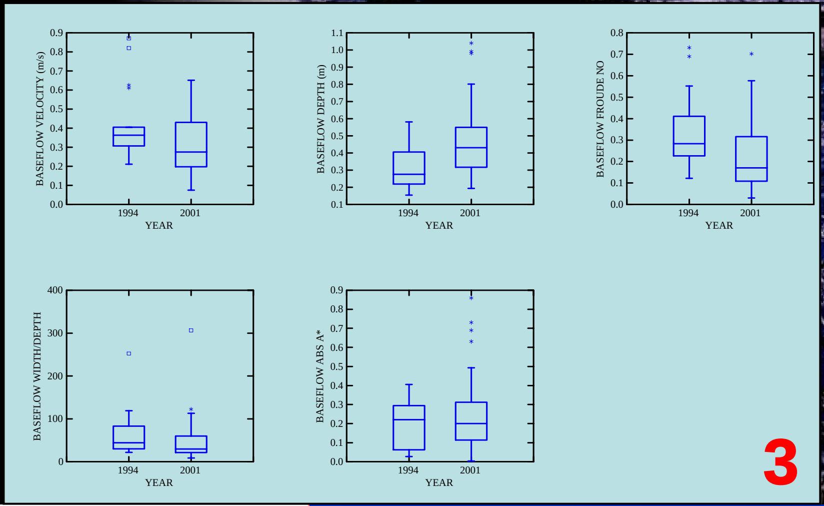
Typical Before XS



Typical After XS

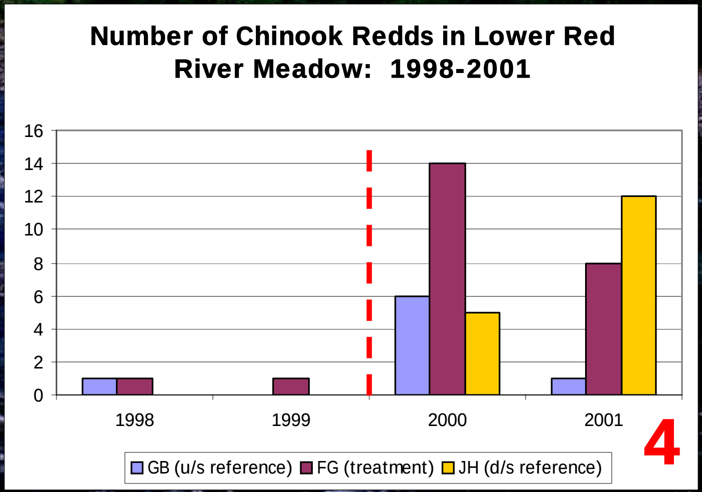


Change in Physical Parameters



?

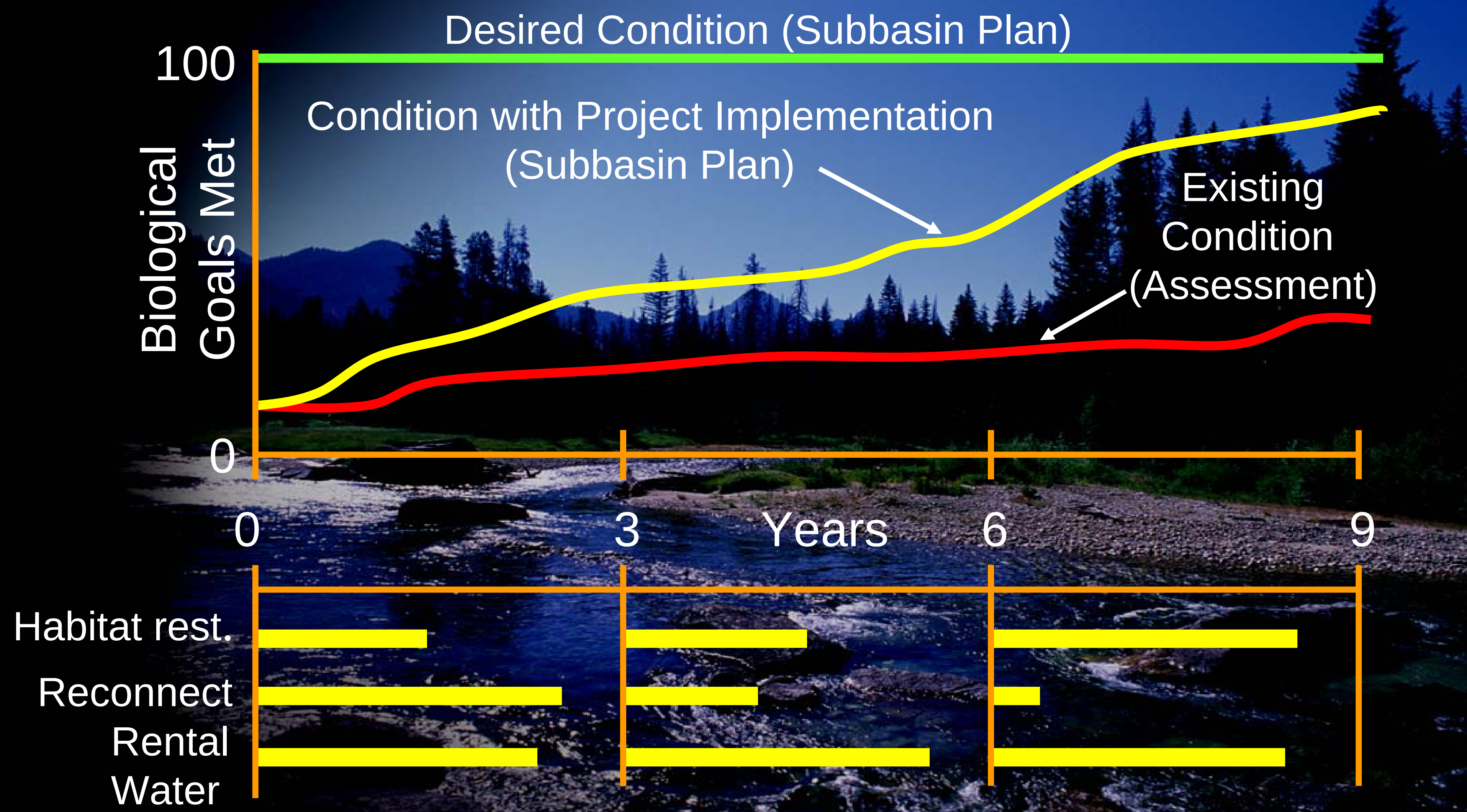
Change in Biological Parameters



Findings

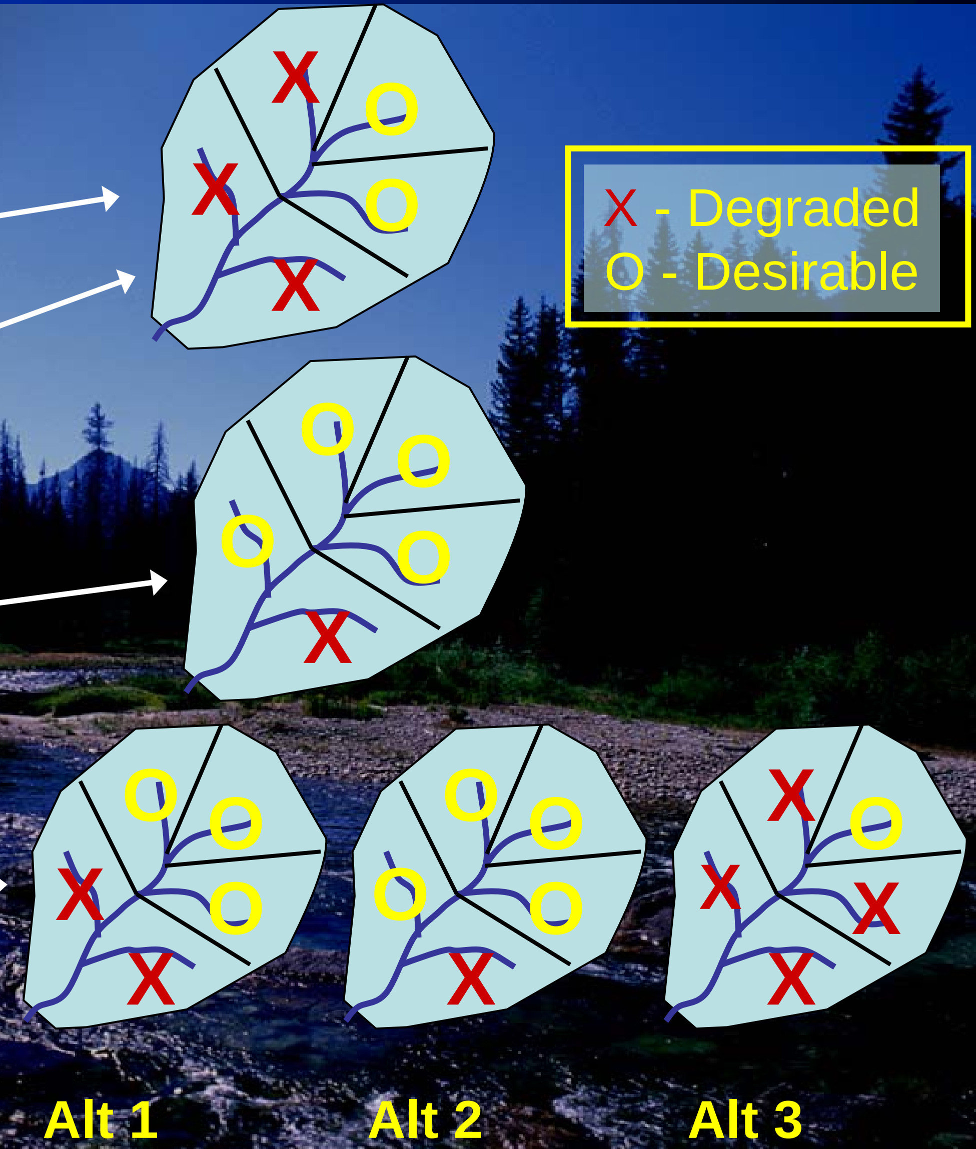
- Critical importance of pre-implementation monitoring data. Data must be consistent with performance monitoring.
- BACI, RIA or other analyses
- Data mining tools: artificial neural networks, genetic algorithms

Example 2: Modeling for Prioritizing Management Actions

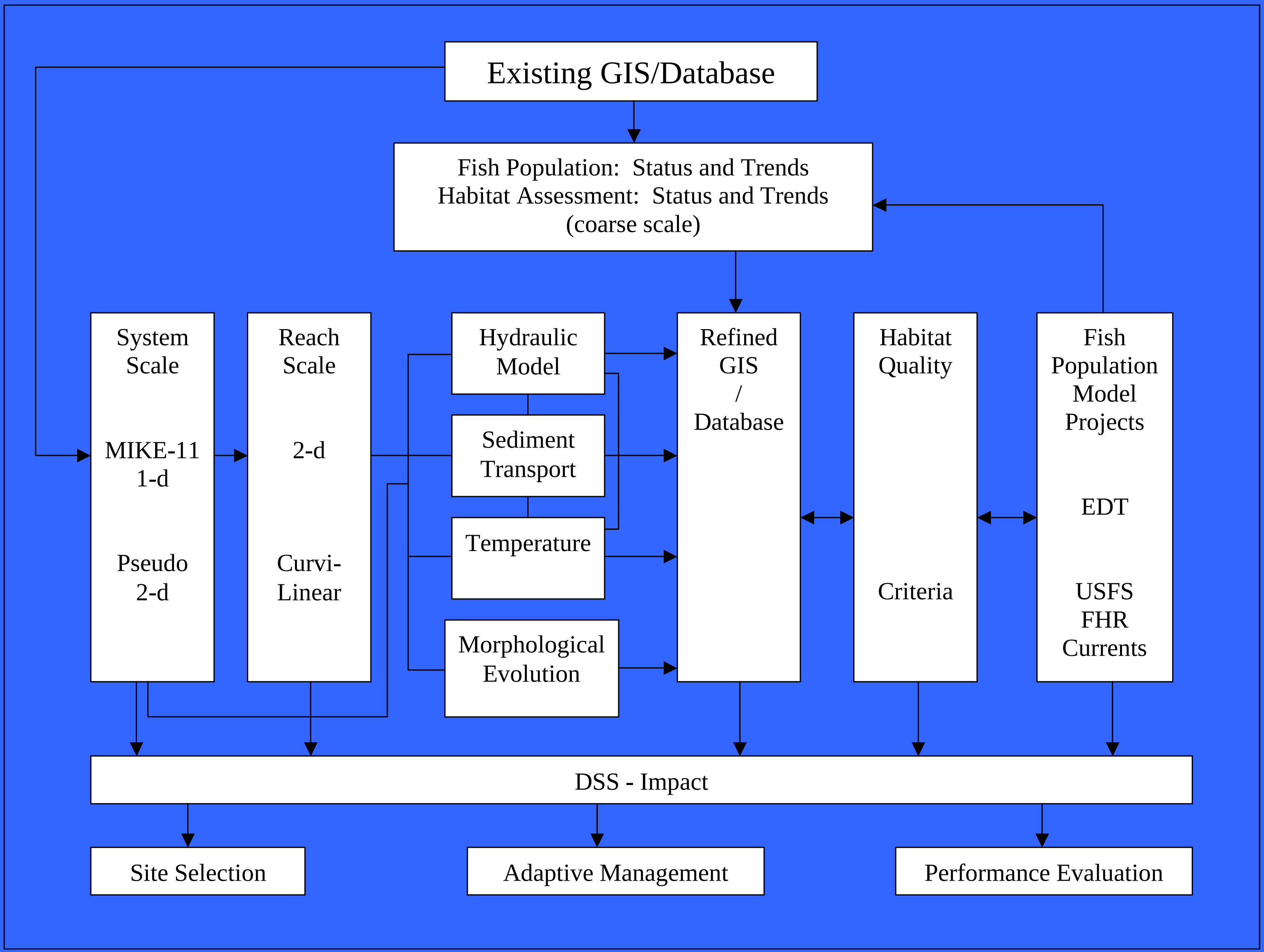


Assessment/Planning

- Current conditions (Assessment)
- Limiting/threatening factors (Assessment)
- Historic/desired conditions (Assessment)
- Plan for reaching goal (Subbasin Plan)



Integrated Modeling Approach



ASSESSMENT ⟷ MODEL

Significance

Magnitude/Trend

Data To Knowledge

– MODEL - discipline knowledge

– ASSESSMENT

Transparent and Defensible

Integrated knowledge across relevant disciplines.

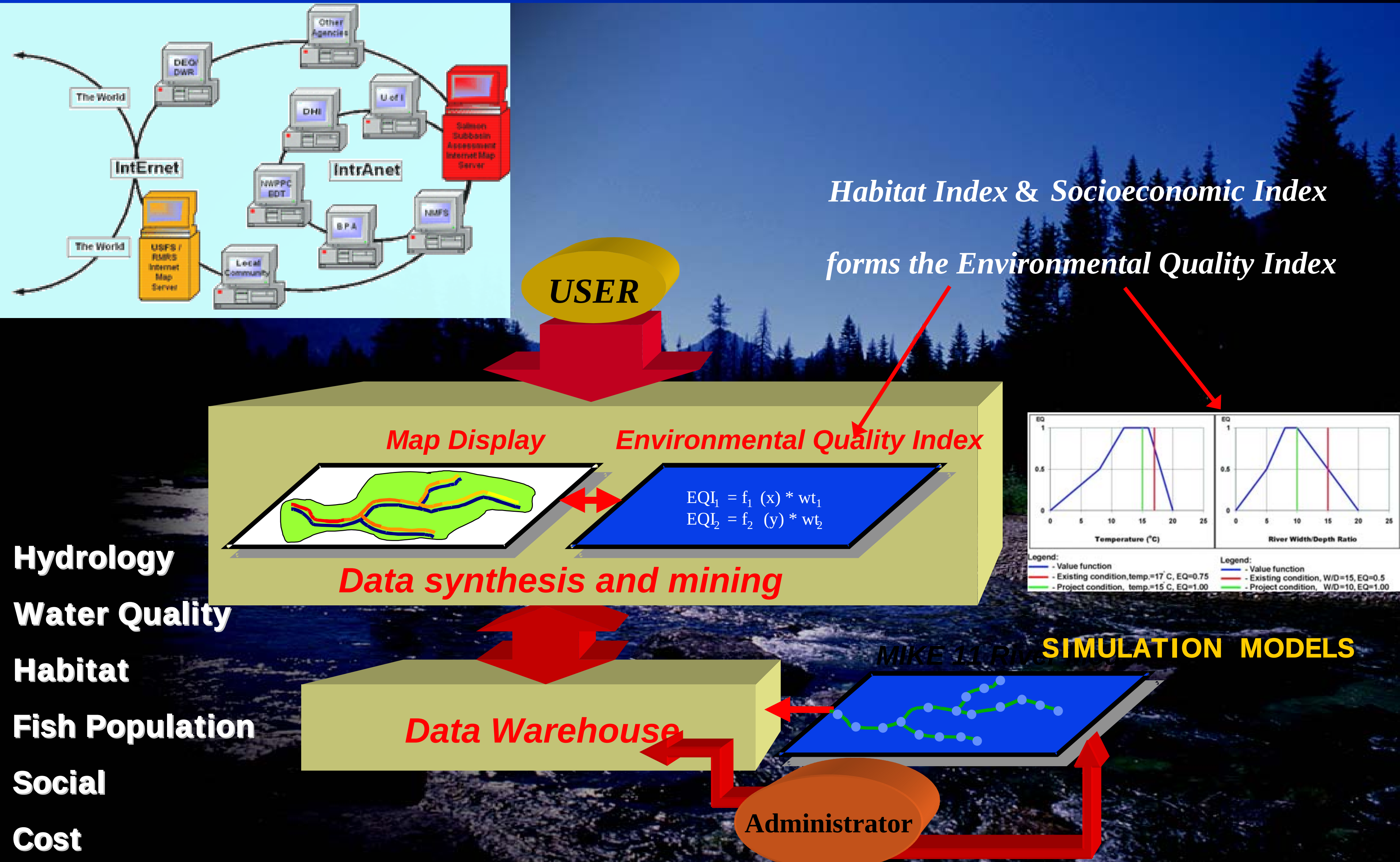
Communication tool.

Integrates local community.

Emerging computational technologies

Impact Objectives

- screen project alternatives for their local and regional environmental benefit
- evaluate a suite of projects or cumulative effects for planning restoration activities in a basin
- develop a ranking system for assessing priority projects
- optimize project design with respect to environmental and/or economic benefits
- view the results in GIS
- transparent and accessible
- multi-scale analysis



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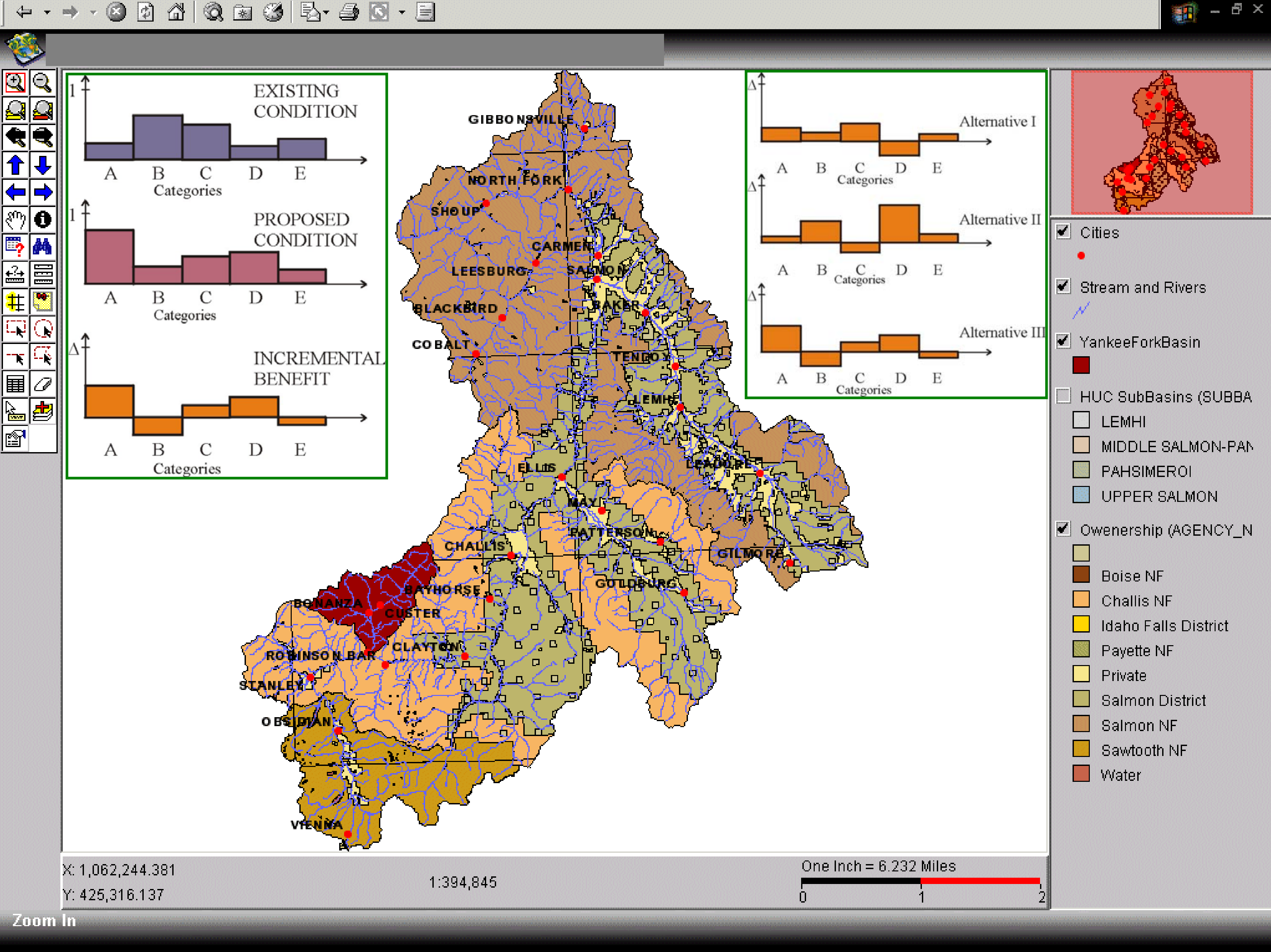

EXISTING CONDITION
A B C D E
Categories
PROPOSED CONDITION
A B C D E
Categories
INCREMENTAL BENEFIT
A B C D E
Categories
Alternative I
A B C D E
Categories
Alternative II
A B C D E
Categories
Alternative III
A B C D E
Categories
GIBBONSVILLE
NORTH FORK
SHOUP
CARMEN
LEESBURG
SALMON
BLACKBIRD
BAKER
COBALT
TENDOY
LEMHI
LEADORE
ELLIS
MAY
PATTERSON
CHALLIS
GILMORE
BAYHORSE
GOLDBURG
BONANZA
CUSTER
ROBINSON BAR
CLAYTON
STANLEY
OBSIDIAN
VIENNA
Cities
Stream and Rivers
YankeeForkBasin
HUC SubBasins (SUBBA
LEMHI
MIDDLE SALMON-PAN
PAHSIMEROI
UPPER SALMON
Owenership (AGENCY_N
Boise NF
Challis NF
Idaho Falls District
Payette NF
Private
Salmon District
Salmon NF
Sawtooth NF
Water
X: 1,062,244.381
Y: 425,316.137
1:394,845
One Inch = 6.232 Miles
0 1 2
Zoom In

Discussion Points

- CBDA is viewed as setting national and international standards for integration of science and policy
- Can CBDA exploit or drive national trends in community science? Sensor networks, cyber-infrastructure, data driven models, emerging data mining tools (GAs and ANNs).
- How can science and technologies be integrated with management and policy decisions
- How can immediate problems be addressed while deepening the fundamental understanding of the complete system to make good decisions in the future?